Earthquakes

By Cynthia A. Malecki

The worst earthquake disaster to hit the United States in recent years was the deadly quake that struck without warning in the Los Angeles, California suburb of Northridge on January 17, 1994. In just 30 seconds, 11,000 homes were destroyed, dozens of freeways were reduced to rubble, and scores of people were killed or injured. Yet before the suddenly shifting tectonic plates triggered the devastation, no one knew this branch of the fault line even existed.
The earth is not a static planet; the large slabs of the earth's crust (tectonic plates) are in continual slow motion. An earthquake occurs when these plates move. The movement causes rock to be squeezed, bent, and stretched. This tremendous pressure eventually forces the rock to break, and the plates lurch into a new position. The underground place where the rock moves or breaks is called the focus. The epicenter is the area directly above the focus on the earth's surface. These movements cause large fractures, or faults, in the earth's crust, and along these fault lines most earthquakes occur. The adjustments that follow a major earthquake often generate smaller quakes called aftershocks. Aftershocks, or tremors, are usually much weaker than the main series of quakes and can follow for months while the area resettles.

The force of these movements sends shock waves in all directions and shakes the ground. Dropping a stone in a still pond will generate a similar type of outward wave that results when two plates come into contact. The intensity of these waves depends on how deep the focus is (up to 700 km, or 450 miles, below ground), how far the rocks move, and the strength of the surrounding rocks. Most earthquakes occur at depths of less than 50 miles from the earth's surface.

The waves caused by the movement of the rocks are called seismic waves. There are two types of seismic waves: surface and body. Surface waves move along the top of the ground in a side-to-side motion or an up-and-down motion. These can cause great damage to building foundations and other structures when they hit cities or towns. Body waves travel through the earth's layers and are further defined as primary or secondary waves. Primary waves (P-waves) travel faster than secondary waves (S-waves) and have a push-pull movement. They push (compress) and pull (expand) the rocks in the direction the wave is traveling. P-waves can travel through the Earth's liquid core, whereas S-waves can travel only through rock. S-waves temporarily change the shape of the material that transmits them in the direction the wave is traveling. Seismic waves—surface, P-waves, and S-waves—are recorded on seismographs located throughout the world at seismic stations.

The study of earthquake waves is called seismology. A scientist who studies earthquakes is a seismologist, and the machine used to record the seismic waves is a seismometer. Seismometers first appeared in China almost two thousand years ago and were designed to determine the direction from which the waves originated. The instrument was invented in 132 A.D. by Chinese philosopher, Zhang Heng, and is reported to have detected an earthquake over 600km, or 372 miles, away. The instrument was sensitive enough to perceive shaking too small to be felt and modern seismographs rely on many of the same principles. Seismographs have a mass freely

suspended from a support that is attached to the ground. When an earthquake shakes the ground, a pen attached to a weight begins to record the vibration on a drum wrapped in paper. The recording produces wiggle lines; the stronger the vibration, the more the pen moves and the larger the wiggle. This recording (a seismogram) allows scientists to tell how weak or strong an earthquake is.

Scientists measure or grade earthquakes according to two scales, the Modified Mercalli and Richter scales. In 1902, Giuseppe Mercalli, an Italian geologist, developed a scale that measures the intensity or amount of shaking and damage to various types of structures at a specific location during an earthquake. Earthquake damage depends on the strength of the earthquake, the distance from the epicenter, the nature of the surface materials, and building design. The intensity of the quake is estimated, according to its effects, on a 12-point scale. For example, a III on the Modified Mercalli scale only rattles windows, whereas a XII brings total destruction.

In 1935, Charles Richter, an American seismologist, invented a scale that assigns each earthquake a rating (or magnitude) based on the height of the tallest wiggle on a seismogram. Magnitude is the measure or amount of energy released during an earthquake. The Richter scale is the measurement most people are familiar with and it rates the amount or magnitude of an earthquake's energy (see Table 1).

Earthquakes can strike anywhere in the world, but through the years they have principally occurred in three large zones of the earth.

The world's largest zone is the rim of the Pacific Ocean (the circum-Pacific seismic belt). It is here that 81 percent of the world's largest earthquakes occur. The belt extends from Chile northward along the western coast of South America, Central America, Mexico, and the United States; and the southern part of Alaska; then through the Aleutian Islands to Japan, the Philippine Islands, New Guinea, the island groups of the southwest Pacific, and to New Zealand. This is an area of young, growing mountains and deep ocean trenches that parallel mountain chains. This area is ripe for earthquakes because of the elevation changes in the mountains—the highest part of the earth's crust—and in the ocean trenches—the lowest part of the crust.

The second zone is the Alpide. This belt extends from Java to Sumatra in Indonesia, though the Himalayas, on to the Mediterranean, and out into the Atlantic. This belt accounts for about 17 percent of the world's largest earthquakes. The third belt follows the submerged mid-Atlantic ridge.

Earthquakes in these prominent zones can be expected, but damaging quakes have been experienced outside these zones. For example, in the United States the New Madrid, Missouri, quake of 1811–12 was actually a series of earthquakes over a three-month period. The three largest quakes had a magnitude over 8.0 on the Richter scale and the approximately 106 aftershocks that followed measured from 4.3 to 8.0. Aftershocks continued to be felt in the region for over a year.

With the development of measuring systems and methods of learning where the majority of earthquakes will originate, you might think that seismologists could predict when the next

earthquake is going to happen. Unfortunately, there isn't a foolproof way of predicting an earthquake—one reliable enough to allow an area to be evacuated in time.

Some people believe that animals are the precursor signals to an earthquake. Helmut Tribush, a German scientist, has devoted years of research to the question of animal sensitivity to earthquakes. The following are a few of his findings:

• Flocks of birds have been reported flying in circles for hours, then suddenly flying away, just before the onset of an earthquake.

• A few hours before an earthquake devastated an Asian village, cats ran out of every house.

• Along the southern coast of Hokkaido (one of the main islands of Japan) before the arrival of an earthquake, thousands of fish jumped into the air, many landing on beaches and dying.

It has also been reported that dogs howl, pandas moan, chickens flee their roosts, and rats and mice scamper from their holes long before any tremors are detected by instruments.

Not all seismologists believe in such sensitivity of animals, and aggressive research to predict earthquakes is under way in Japan, the United States, and Russia—countries where earthquake risk is high. No reliable short-range prediction methods are available, and long-range forecasts are based on the premise that earthquakes are repetitive and cyclical. Seismologists are studying the history of earthquakes so their occurrences might be predicted.

Significant earthquakes:

The biggest earthquake since 1900 occurred in Chile on May 22, 1960. The quake had a magnitude of 9.5 and resulted in over 6,000 deaths. The quake also triggered a tsunami (tidal wave) that killed people as far away as Hawaii and Japan.

The largest earthquake in the United States was the March 27, 1964, Good Friday quake in Alaska. It had magnitude of 9.2, and 115 people were killed in a tsunami caused by the quake. Shaking was felt for an estimated seven minutes, and the ground was lowered and raised from 2 meters (6.5 feet) to 17 meters (56 feet.) in some areas.

The Shansi, China earthquake of 1556 had the greatest number of fatalities—an estimated 830,000 people perished.

The Kobe earthquake of 1995 was one of Japan's worst. It measured 6.8 on the Richter scale, lasted approximately 30 seconds, and left 5,502 dead, 36,896 injured, and about 310,000 homeless. It destroyed major sections of the city of Kobe and surrounding villages.

In 1999, Turkey experienced seven earthquakes in five months. On August 17, the quake measured 7.8 on the Richter scale and the duration of strong shaking was felt for 37 seconds.

That quake caused 17,118 deaths and over 50,000 injuries. Thousands of people were missing, and over 600,000 were left homeless. The six other quakes ranging from 4.2 to 7.5 on the Richter scale caused approximately 850 deaths and 5,700 injuries.

An 8.1 earthquake occurred on September 19, 1985 in Michoacan, Mexico. At least 9,500 people were killed and about 30,000 were injured. More than 100,000 people were left homeless. Severe damage was caused in parts of Mexico City and in several states of central Mexico. According to some sources, the death toll from this earthquake may be as high as 35,000. It is estimated that the quake seriously affected an area of approximately 825,000 square kilometers and was felt by almost 20 million people. In Mexico City, 412 buildings collapsed and another 3,124 were seriously damaged.

On December 7, 1988, the Turkey-USSR border region experienced a 6.8 earthquake on the Richter scale, leaving at least 25,000 people dead, 19,000 injured and 500,000 homeless in the Leninakan-Spitak-Kirovakan area of northern Armenia. More than 20 towns and 342 villages were affected, and 58 of them were completely destroyed.

On June 20, 1990, a 7.7 earthquake hit western Iran. Considered one of the most destructive on record, between 40,000 to 50,000 people were killed, more than 60,000 were injured, and 400,000 or more were left homeless. There was additional extensive damage caused by accompanying landslides.

Earthquake survival

There are several important preparations you can make before an earthquake:

Prepare for an emergency at home:

Ensure all family members know how to turn off the gas, water, and electricity in your house or apartment.

Plan family emergency procedures; make plans for reuniting family members after an earthquake.

Know emergency numbers, including police, hospital, and doctor.

Anchor heavy objects (bookcases, mirrors, cabinets, and so forth) to walls.

Never place heavy objects over beds, and keep heavy objects lower than the head height of the shortest member of the family.

If you are caught during an earthquake:

Stay calm.

If you’re inside, stand in a doorway or crouch under a desk or table well away from windows or other glass.

If you're outside, stand away from buildings, trees, and telephone and electrical lines.

On the road, drive away from underpasses and overpasses, stop in safe areas, and stay inside the vehicle.

After an earthquake:

Check for injuries and provide first aid.

Check for safety—turn off gas, water, or sewage breaks; watch out for downed power lines and short circuits.

Check for building damage and potential problems should aftershocks occur.

Clean up dangerous spills.

Wear shoes.

Turn on the radio and listen for instructions from public safety agencies.

Make an earthquake emergency supply kit:

Supplies should last for 72 hours (3 days).

Fire extinguisher

Adequate supplies of medications that you or family members are taking

Wrenches to turn off gas and water supplies

First-aid kit

Flashlights with extra bulbs and batteries

Portable radio with extra batteries

Water for each family member (2 to 4 liters, or 1 gallon, per person per day)

Canned and packaged foods and can opener

Camp stove or barbecue to cook outdoors

Waterproof, heavy-duty plastic bags for waste disposal

Earthquake Web sites of interest

These are some of the Web sites dealing with earthquakes that have links to educational, research, and reference libraries.

http://pubs.usgs.gov/publications/text/preface.html
"The Dynamic Earth" by U.S. Geological Survey (USGS) is a booklet about plate tectonics that can be downloaded.

http://iris.washington.edu/EandO
The IRIS Education and Outreach program, in collaboration with seismologists, has developed this Web site to enhance seismology and earth science education in primary and secondary schools. The site contains worksheets to download and links to other educational sites.

http://pasadena.wr.usgs.gov/eqhaz/faq/eqfaq.html
A Web site containing useful information and answers to questions about earthquakes.

http://neic.usgs.gov
The National Earthquake Information Center and World Data Center for Seismology Web site contains current worldwide earthquake information. You can search for information on earthquakes and read about the largest 1999 and 2000 earthquakes.

http://www.usgs.gov/education
This USGS Web site explores the earth's plants, animals, land, and water. It explains how biology, geology, hydrology, and geography can help us understand our changing world.

http://vcourseware4.calstatela.edu/GeoLabs/index.html
Virtual Earthquake is an interactive tutorial that helps students understand how the epicenters of earthquakes are located using seismograms and how Richter magnitudes are determined. At the end of the interactive session you can get a certificate of completion.

http://sridhar_h.tripod.com/calif.html
This Web site is strictly for fun.